GREEN INTERIOR DESIGN AND CONSTRUCTION

LEED Reference Guide for Green Interior Design and Construction

2009 Edition

CONSTRUCTION INDOOR AIR QUALITY MANAGEMENT PLAN—BEFORE OCCUPANCY

IEQ CREDIT 3.2

	CI
Credit	IEQ Credit 3.2
Points	1 point

Intent

To reduce indoor air quality (IAQ) problems resulting from construction or renovation and promote the comfort and well-being of workers and occupants.

Requirement

Develop an IAQ management plan and implement it after all finishes have been installed and the building has been completely cleaned before occupancy.

OPTION 1. Flush-Out[1]

PATH 1

After construction ends, prior to occupancy and with all interior finishes installed, install new filtration media and flush-out the building by supplying a total air volume of 14,000 cubic feet of outdoor air per square foot of floor area while maintaining an internal temperature of at least 60oF and, where mechanical cooling is operated, relative humidity no higher than 60%.

OR

PATH 2

If occupancy is desired prior to completion of the flush-out, the space may be occupied following delivery of a minimum of 3,500 cubic feet of outdoor air per square foot of floor area. Once the space is occupied, it must be ventilated at a minimum rate of 0.30 cubic feet per minute (cfm) per square foot of outside air or the design minimum outside air rate determined in EQ Prerequisite 1: Minimum IAQ Performance, whichever is greater. During each day of the flush-out period, ventilation must begin a minimum of 3 hours prior to occupancy and continue during occupancy. These conditions must be maintained until a total of 14,000 cubic feet per square foot of outside air has been delivered to the space.

OR

OPTION 2. Air Testing

Conduct baseline IAQ testing after construction ends and prior to occupancy, using testing protocols consistent with the EPA Compendium of Methods for the Determination of Air Pollutants in Indoor Air and as additionally detailed in the LEED Reference Guide for Green Interior Design and Construction, 2009 Edition.

1 All finishes must be installed prior to flush-out

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Demonstrate that the contaminant maximum concentration levels listed below are not exceeded:

Contaminant	Maximum Concentration
Formaldehyde	27 parts per billion
Particulates (PM10)	50 micrograms per cubic meter
Total volatile organic compounds (TVOCs)	500 micrograms per cubic meter
4-Phenylcyclohexene (4-PCH)*	6.5 micrograms per cubic meter
Carbon monoxide (CO)	9 part per million and no greater than 2 parts per million above outdoor levels

*This test is required only if carpets and fabrics with styrene butadiene rubber [SBR] latex backing are installed as part of the base building systems.

For each sampling point where the maximum concentration limits are exceeded, conduct an additional flush-out with outside air and retest the noncompliant concentrations. Repeat until all requirements have been met. When retesting noncompliant building areas, take samples from the same locations as in the first test.

Conduct the air sample testing as follows:

- All measurements must be conducted prior to occupancy, but during normal occupied hours, with the building ventilation system started at the normal daily start time and operated at the minimum outside air flow rate for the occupied mode throughout the test.
- All interior finishes must be installed, including but not limited to millwork, doors, paint, carpet and acoustic tiles. Movable furnishings such as workstations and partitions must be in place.
- The number of sampling locations will depend on the size of the building and number of ventilation systems. For each portion of the building served by a separate ventilation system, the number of sampling points must not be less than 1 per 25,000 square feet or for each contiguous floor area, whichever is larger. Include areas with the least ventilation and greatest presumed source strength.
- Air samples must be collected between 3 and 6 feet from the floor to represent the breathing zone of occupants, and over a minimum 4-hour period.

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1. Benefits and Issues to Consider

Environmental Issues

Reducing contaminants inside buildings results in greater occupant comfort, lower absenteeism, and improved productivity. Construction inevitably introduces contaminants to building interiors. If unaddressed, contamination can result in poor IAQ extending over the lifetime of a building. Fortunately, there are IAQ management strategies that, if instituted during construction and before occupancy, will minimize potential problems (see Implementation).

Economic Issues

Additional time and labor may be required during construction to protect and clean ventilation systems and building spaces. These actions can extend the lifetime of ventilation systems and improve their efficiency, resulting in reduced energy use. The sequencing of material installation so as to reduce contamination may require additional time and could potentially delay occupancy. However, early coordination between the design team, contractor, and subcontractors can minimize or eliminate scheduling delays.

2. Related Credits

Comprehensive construction IAQ management consists of best practices both during construction and after construction, prior to occupancy. These activities are typically governed by the same management plan. The following credit also requires development and implementation of a construction IAQ management plan:

- IEQ Credit 3.1: Construction IAQ Management Plan During Construction

The materials that are specified and installed within the external moisture barrier of the building, as well as filtration, can directly affect air quality and influence the results for air quality testing. Refer also to the following credits:

- IEQ Credit 4: Low-Emitting Materials
- IEQ Credit 5: Indoor Chemical and Pollutant Source Control

Dilution of indoor air contaminants can typically be achieved by introducing outdoor air. The following credit and prerequisite deal with ventilation rates:

- IEQ Prerequisite 1: Minimum Indoor Air Quality Performance
- IEQ Credit 2: Increased Ventilation

3. Summary of Referenced Standard

U.S. EPA Compendium of Methods for the Determination of Air Pollutants in Indoor Air

This standard is available from NTIS (800) 553-6847 with the ordering number PB90200288.

According to the Compendium, the EPA created this document to "provide regional, state and local environmental regulatory agencies with step-by-step sampling and analysis procedures for the determination of selected pollutants in indoor air. Determination of pollutants in indoor air is a complex task, primarily because of the wide variety of compounds of interest and the lack of standardized sampling and analysis procedures. The Compendium has been prepared to provide a standardized format for such analytical procedures. A core set of 10 chapters with each chapter containing 1 or more methods are presented in the current document. Compendium covers a variety of active and passive sampling procedures, as well as several analytical techniques both on and off site."

4. Implementation

Flush-Out Procedure

This compliance path uses the building HVAC system to evacuate airborne contaminants. Complete all construction work, including punch-list items, before beginning the flush-out. Finalize all cleaning prior to the flush-out. Complete the final test and balancing of HVAC systems, and make sure the HVAC control is functional, especially if the occupants will be moving in during the second phase of the flush-out. Commissioning can occur during the flush-out if it does not introduce any additional contaminants into the building.

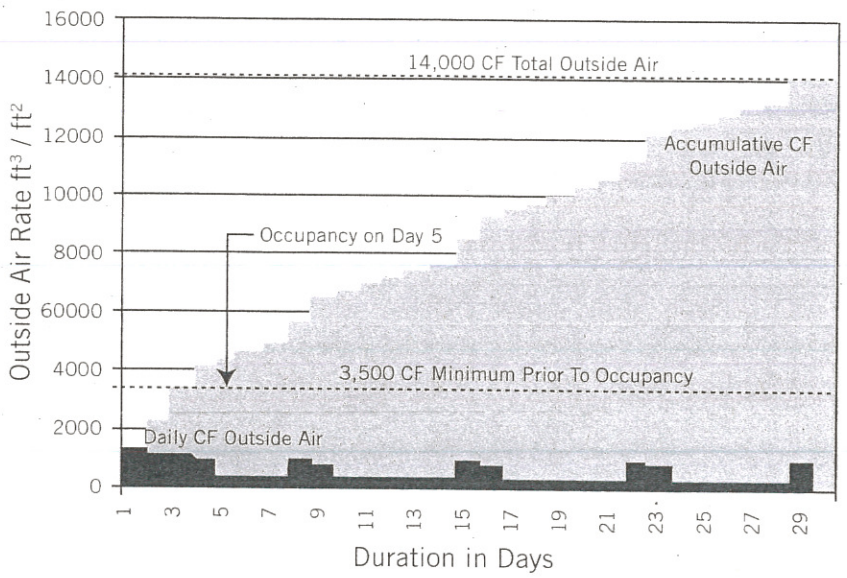
The flush-out procedure discussed below assumes the use of the building's HVAC system, but alternatives are acceptable if they meet the air quantity, temperature, and humidity requirements.

One approach uses temporary supply and exhaust systems placed into windows or window openings. EPA's Indoor Air Quality Tools for Schools website provides information on exhaust and spot ventilation during construction that can be helpful for design teams considering using this approach. Make sure the air flow is not short circuited, which could leave remote corners of the project spaces with inadequate circulation or cause unanticipated increases in other parts of the building, such as a stack effect in elevator shafts.

If the space's central HVAC system is used, the team should remove any temporary filters and duct coverings installed as part of the construction IAQ management plan. The team should replace the HVAC filtration media with new media; if the system is configured to filter only outside air, the filters do not need to be replaced. New filters that meet the design specification and were installed prior to the start of flush-out will also satisfy the requirements of IEQ Credit 3.1, Construction IAQ Management Plan During Construction. Note that these filters must be MERV 13 or better when a project plans to earn IEQ Credit 5, Indoor Chemical and Pollution Source Control. Depending on their condition following flush-out, some or all of the filters might be ready for replacement, but this is not a condition for satisfying the credit requirements.

Outside air is used to dilute and remove off-gassed contaminants. The quantity of outside air that must be introduced to the project space for the flush-out is 14,000 cubic feet of air per square foot of floor area. Occupants may move in only after the initial flush out phase, when 3,500 cubic feet of air per square foot has been replaced (Figure 1). The initial flush-out phase does not signal the completion of the flush-out, however: A total of 14,000 cubic feet of outside air must be supplied per square foot of floor area before the HVAC system is switched to its normal operational mode.

Figure 1. Sample Air Quantity for Flush-Out



Not all outside air is equal. Depending upon geography and season, outside air can be very cold or damp. Because of this, prudent limits have been set to ensure no harm comes to the building and occupants. The rate of outside air should not cause the interior temperature to drop below 60°F, and relative humidity should not exceed 60%.

During an occupied flush-out phase, a minimum ventilation rate must begin at least 3 hours before daily occupancy and continue while the space is occupied. The rate of outside air must be at least 0.30 cubic feet per minute (cfm) per square foot or the design minimum outside air rate, whichever is greater. The design minimum outside air rate should be determined using ASHRAE 62.1–2007, the same criteria for IEQ Prerequisite 1, Minimum Indoor Air Quality Performance, or the applicable local code if it is more stringent. The 0.30 cfm per square foot rate may be several times the ASHRAE 62.1–2007 requirement for a project's planned occupancy. As a result, consider the minimum flush-out rate during early HVAC design.

There are other thermal comfort, expense, and operational considerations to evaluate when preparing tooccupy a space before the end of flush-out. Check to make sure the HVAC system can maintain temperatures within a range that is comfortable for the occupants; opinions formed during this period may last long after the system is operating normally.

There are numerous expense and operational issues to consider, such as the rent or lease details and the existing HVAC system capacity to accommodate the flush-out criteria. Input from the entire project team will help determine the best approach. When completed, make the evaluation and the resulting flush-out strategy part of the project construction IAQ management plan.

When there are multiple HVAC systems that can operate independently, it is acceptable to flush out portions of the building as they are completed, but no additional construction work can occur once the flush-out of an area begins. Isolate completed areas from those under construction per SMACNA IAQ Guidelines for Occupied Buildings under Construction.

Air Quality Testing

The baseline IAQ testing approach is meant to confirm that major contaminants are below recognized acceptable levels before occupancy. While the list included in the credit is not intended to be all-inclusive, it approximates the major forms of postconstruction airborne constituents.

Testing results that meet the credit requirements indicate that the project has implemented a successful construction IAQ management plan, low-emitting materials have been specified, cleanup has been thorough, and the HVAC system is providing adequate ventilation. They can also mean that occupancy can occur sooner than what might have been possible if the flush-out compliance path had been followed. Ideally, the groundwork should be laid for baseline testing during the design process by making sure the testing requirements are included in Division 1 of the project construction specifications. This credit does not establish qualifications for the laboratory or those conducting the sampling; however, the project team should evaluate the capabilities of the IAQ specialist, industrial hygienist, and testing facility being considered for field sampling of IAQ in buildings.

During construction, be vigilant about avoiding substitutions for the specified low-emitting materials. Use low-VOC cleaning supplies to prevent short-term high-VOC levels that may affect test results. Use vacuum cleaners with HEPA filtration to capture particulates.

Projects also following the requirements of IEQ Credit 3.1, Construction IAQ Management Plan During Construction, should replace all filtration media after the final cleaning and complete the air test and balancing of the HVAC system before beginning the baseline IAQ testing. The IAQ maximum contaminant levels are dependent on the HVAC system operating under normal conditions with outdoor airflow rates at the minimum; this stipulation is made so that the air tested is as similar

as possible to what the occupants will be breathing. The protocols described in the referenced publication, EPA's Compendium of Methods for the Determination of Air Pollutants in Indoor Air, are recommended, but others may be used if the project team can provide valid justification. The project team should select the sampling locations carefully to find the concentrations in areas with the least ventilation and, potentially, the greatest presumed contaminant source strength. The team should take at least 1 sample per 25,000 square feet in each portion of the building served by a separate ventilation system. For example, in a 20,000-square-foot tenant space served by 3 rooftop units—1 each for the north and south elevations (general office area) and the third for a training room and conference rooms—the project team should take samples in at least 3 places, even though 2 units serve 1 general office area. The team should take the samples in the breathing zone, between 3 feet and 6 feet above the floor, during normal occupied hours, with the HVAC system operating at normal daily start times, and with the minimum outside airflow rate. Follow-up samples might be needed, so the project team should record the exact sample locations. If a test sample exceeds the maximum concentration level, the team should flush out the space by increasing the rate of outside air. While the credit requirements do not prescribe the duration of the flush-out, those responsible for testing should make an evaluation based on the contaminant, its concentration, and the potential source. Off-gassing characteristics of sources differ; some deplete rapidly, while others emit at a steady rate over an extended period of time. The project team should resample and confirm compliance before allowing occupancy. The retest may be limited to the chemical contaminants that produced excessive chemical concentration levels in the initial test.

5. Timeline and Team

During the design phase, include language requiring the general contractor to develop and implement a construction IAQ management plan that includes a compliant flush-out procedure and/or air quality testing that meets the requirements of this credit.

After construction and installation of all finishes (including furniture and furnishings), conduct IAQ testing and/or a flush-out following the construction IAQ management plan and in accordance with the requirements of this credit.

Some additional time and labor may be required during and after construction to protect and clean ventilation systems. With early coordination for the sequencing of material installation and coordination between the contractor and subcontractors, the team can minimize or eliminate scheduling delays.

6. Calculations

If a building flush-out is performed before occupancy, the total quantity of outdoor air that must be delivered to the space is calculated as follows:

Phased flush-out:

Phase 1

Building Area (sf)	X	3,500 ft of Outdoor Air	=	Cubic Feet of Air Needed Prior to Occupancy

Phase 2

Building Area (sf)	X	10,500 ft of Outdoor Air	=	Cubic Feet of Air Needed to Complete Flush-Out

Nonphased flush-out:

Building Area (sf)	X	14,000 ft of Outdoor Air	=	Cubic Feet of Air Needed Prior to Occupancy

Note: feet of outdoor air = cubic feet per square foot

7. Documentation Guidance

As a first step in preparing to complete the LEED-Online documentation requirements, work through the following measures. Refer to LEED-Online for the complete descriptions of all required documentation.

- Maintain a written construction IAQ management plan.
- Record dates, occupancy, outdoor air delivery rates, internal temperature, humidity, and any special considerations for projects completing a flush-out procedure.
- Maintain a copy of the testing report and verify that all required contaminants are accounted for and are reported in the correct unit of measure for projects completing IAQ testing.

8. Examples

Table 1. Time for Flush-Out Options

	Square Foot of Office	Outdoor Air Required for Flush-Out (cfm/sf)	Volume of Air Required Before Occupancy (cu. ft.)	Time Before Occupancy (days)	Minimum Outdoor Air Delivery Rate Post-Occupancy (cfm)	Time to Complete Flush-Out at Minimum Delivery Rate (days)
Pre-Occupancy Option	50,000	14,000	700,000,000	32.4	0	0
Post-Occupancy Option	50,000	14,000	175,000,000	8.1	15,000	24.3
Note: Assuming the building has a 15,000 cfm air handler, capable of operating at 100% OA while maintaining 60° F and 60% RH 24 hr/day						

9. Exemplary Performance

This credit is not eligible for exemplary performance under the Innovation in Design section.

10. Regional Variations

For projects that pursue this credit through the flush-out options in regions where there may be humid and/or cold outdoor air, the project team should be sure to maintain the indoor air temperature at or above 60°F and maintain the relative humidity at or below 60%. When weather conditions may impact the ability to sufficiently heat, cool, or dehumidify the supply air, careful coordination between the project schedule and seasonal variations is crucial.

11. Operations and Maintenance Considerations

Minimize potential sources of indoor air contamination. If such sources must be introduced, consider flushing out the affected areas of the building before those areas are occupied.

Use periodic IAQ testing to verify safe, healthful conditions.

If applicable, provide building operators with information about the flush-out procedures used during construction to facilitate adoption of similar practices following future alterations or additions. Encourage them to draft an IAQ management plan, following the LEED for Existing Buildings: O&M guidance, for any future alterations and additions.

12. Resources

Please see USGBC's LEED Registered Project Tools (http://www.usgbc.org/projecttools) for additional resources and technical information.

Websites

Indoor Air Pollution Report, July, 2005
California Air Resources Board
http://www.arb.ca.gov/research/indoor/ab1173/finalreport.htm

Controlling Pollutants and Sources, IAQ Design for Schools
U.S. EPA
http://www.epa.gov/iaq/schooldesign/controlling.html
This EPA website offers detailed information on exhaust or spot ventilation practices during construction activity.

State of Washington Program and IAQ Standards
http://www.aerias.org/DesktopModules/ArticleDetail.aspx?articleId=85
This standard was the first state-initiated program to ensure the design of buildings with acceptable IAQ.

Sheet Metal and Air Conditioning Contractors' National Association
http://www.smacna.org
SMACNA is an international organization that developed guidelines for maintaining healthful indoor air quality during demolitions, renovations, and construction. They publish *Indoor Air Quality: A Systems Approach, which* covers air pollutant sources, control measures, IAQ process management, quality control and documentation, interpersonal communication , sample projects, tables, references, resources, and checklists.

Print Media

Indoor Air Quality: a Facility Manager's Guide, Construction Technology Centre Atlantic, is written as a comprehensive review of IAQ issues and solutions. Purchase the report online at http://ctca.unb.ca/CTCA/communication/IAQ/Order_IAQ.htm.

Compendium of Methods for the Determination of Inorganic Compounds in Ambient Air
U.S. EPA
This standard is available for purchase from NTIS.

13. Definitions

A **construction IAQ management plan** outlines measures to minimize contamination in a specific building during construction and to flush the building of contaminants before occupancy.

Contaminants are unwanted airborne constituents that may reduce air quality (ASHRAE 62.1–2007).

HVAC systems are the equipment, distribution systems, and terminals that provide the processes of heating, ventilating, or air-conditioning (ASHRAE 90.1–2007)

Indoor air quality (IAQ) is the nature of air inside a building that affects the health and well-being of building occupants. It is considered acceptable when there are no known contaminants at harmful concentrations as determined by cognizant authorities and with which a substantial majority (80% or more) of the people exposed do not express dissatisfaction. (ASHRAE 62.1–2007)

Off-gassing is the emission of volatile organic compounds (VOCs) from synthetic and natural products.

Thermal comfort exists when building occupants express satisfaction with the thermal environment.

Outdoor air is the ambient air that enters a building through a ventilation system, either through intentional openings for natural ventilation or by infiltration. (ASHRAE 62.1–2007)

Ventilation the provision and removal of air to control air contaminant levels, humidity, or temperature within an indoor space. Ventilation is measured in air changes per hour—the quantity of infiltration air in cubic feet per minute (cfm) divided by the volume of the room. (ASHRAE 62.1–2007)